PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to the Cold Working of Metal

We, AMERICAN RADIATOR & STANDARD SANITARY CORPORATION, a Corporation organised under the laws of the State of Delaware, United States of America, of 40, West 40th Street, City of New York, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates generally to cold working or shaping tubular steel articles such as hollow plugs or inserted fittings, and more particularly to cold forming, a generally cup-shaped steel article having a bottom wall of desired thickness, and tubular side walls of different or varying thicknesses providing an annular shoulder adjacent the open end of the article with a thinner annular terminal side wall above the shoulder extending to the open end of the cup-shaped article.

Plugs of this general character may be finally finished by any desired operations to provide either internal or external threads, undercut internal recesses and a necked-in portion in the thinner side wall above the internal shoulder or an external flange depending upon the ultimate use thereof.

Heretofore, steel plugs of this character have been formed either as castings or forgings and machined, heat treated and ground where high strength is required; or such articles could be made as an automatic screw machine product by machining bar stock and then heat treating to develop desired physical characteristics.

Each of these modes of manufacture of such a plug product involves considerable expense and metal loss and may require a special alloy steel as a raw material if desired physical characteristics must be developed by heat treatment.

According to the present invention a method of cold forming a steel article having a tubular side wall and a bottom wall and having an internal angular shoulder and an annular terminal wall portion above the shoulder and thinner than the side wall portion below the shoulder, comprises pushing through a restricted opening a cup shaped blank having a central cavity with a bottom wall, an annular side wall and an angular annular shoulder at the open end of the side wall, by applying a pushing force to the cup bottom wall to push the cup shaped blank through said restricted opening thereby drawing, elongating and thinning the cup side wall between the bottom wall and said angular annular shoulder, continuing to push the cup bottom wall until the cup side wall has been elongated sufficiently to establish a predetermined height from the cavity bottom wall to said angular annular shoulder, and then applying axial pressure to said angular annular shoulder to first rearwardly extrude metal from the cup side wall to form said terminal wall portion above said shoulder and then to draw and elongate the metal in said terminal wall.

The cup shaped blank is preferably formed by cold working a disc like steel starting blank by axially pressing and radially squeezing said starting blank to size the same to be truly concentric and to form said angular annular shoulder surrounding a concentric recess in the top of the blank, and then axially squeezing the sized blank to form said cup-shaped blank.

The starting blank may be a typical button-like slug punched out in forming an opening in a steel wall and which button-like slug has heretofore normally been considered scrap material. Thus, according to a further feature of the invention a method of cold working a solid steel blank, comprises the steps of providing a disc-like steel starting blank, successively subjecting the blank to a series of axial compressions while laterally confining the same to progressively decrease the diameter of the blank and to first increase and then decrease the axial thickness of the blank in the vicinity of its axis and to form a cup-shaped article with tubular side walls, initially forming an angular annular shoulder in the top surface of the blank during the first axial pres-

sure application, maintaining said angular annular shoulder throughout subsequent axial pressure applications, during which pressure applications side walls are formed in the blank, and during the last stages of the final axial pressure application pressure being applied to said shoulder to rearwardly extrude and draw metal from the blank side walls to form a thin annular terminal side wall portion above said shoulder to produce a finished cylindrical cup-shaped article with tubular side walls terminating in a thin annular portion. The thin terminal side wall may subsequently be necked in or nosed in.

The invention will be more particularly described by way of example, with reference to the accompanying drawings which illustrate a preferred embodiment and in which:—

Fig. 1 is a perspective view of a metal blank which is used as a starting blank in the cold forming method of the present invention,

Fig. 2 is a somewhat diagrammatic sectional view illustrating the first or slug sizing step of the new cold forming method with the blank of Fig. 1 located in a die cavity prior to cold working the blank,

Fig. 3 is a view similar to Fig. 2 showing the sized blank formed as a result of applying axial pressure to the blank in the die cavity of Fig. 2,

Fig. 4 is a view similar to Fig. 2 showing the sized blank in a die cavity for reshaping the same to cup-form, prior to applying axial pressure to the blank;

Fig. 5 is a view similar to Fig. 4 showing a cup-shaped blank formed in the die of Fig. 4 by backward extrusion;

Fig. 6 is a view similar to Figs. 2 and 4 showing the cup-shaped blank located in a die cavity prior to pushing the blank through a reduced die cavity opening;

Fig. 7 is a view similar to Fig. 6 showing the blank after diameter reduction and side wall elongation in the die illustrated in Fig. 6;

Fig. 8 is a fragmentary somewhat diagrammatic sectional view showing the formed blank of Fig. 7 in a nosing die prior to the operation of the die;

Fig. 9 is a view similar to Fig. 8 showing the nosing die at the completion of its operation;

Fig. 10 is a sectional view of the blank illustrated in Fig. 1 used as a starting blank for the operations shown in Figs. 2 and 3;

Fig. 11 is a sectional view of the blank produced by the operations shown in Figs. 2 and 3;

Fig. 12 is a view similar to Fig. 11 illustrating the blank produced by the operations shown in Figs. 4 and 5;

Fig. 13 is a view similar to Fig. 12 showing the blank produced by the operation shown in Figs. 6 and 7;

Fig. 14 is a view similar to Fig. 13 showing the completed nosed-in cold-formed product made by the operation shown in Figs. 8 and 9;

Fig. 15 is a diagrammatic view illustrating the typical machining operations which may be performed on the cold formed product of Fig. 14 to provide an internally recessed steel plug or fitting;

Fig. 16 is a view similar to Fig. 14 showing a modified form of cold-formed product with an outwardly formed flange; and

Fig. 17 is an enlarged view of a portion of Fig. 7.

Similar numerals refer to similar parts throughout the various figures of the drawings.

In the drawings, the improved method illustrates the manufacture of a hollow plug or fitting which may be used as an inserted fitting for many purposes. However, the invention is not limited to the manufacture of the particular articles illustrated, inasmuch as the discoveries of the present invention may be used generally in the manufacture of cup-shaped articles the manufacture including the formation of a shouldered internal recess and a thin annular terminal wall on the cup-shaped article.

The starting blank for the new method is indicated at 1 in the drawings and is illustrated as a scrap-slug-punching normally produced as scrap in punching a hole through a wall of a steel article of approximately the thickness of the slug 1. In Figs. 1 and 10, the slug 1 is illustrated inverted with respect to its position as punched out of a hole formed in a steel wall, the characteristic slight convexity of the bottom of the punched out slug being indicated at the top of the blank 1 in Fig. 10 at 2, and the characteristic annular sheared surface of a punched out slug being indicated at 3 in Figs. 1 and 10.

Although the use of a scrap-slug-punching as a starting blank is preferred for the purposes of the present invention where such scrap steel is available because of the reduced cost thereof, it is understood that the starting blank for the new method, indicated at 1 in the drawings, may be a cylindrical disc or button-like slug which may be cut from bar stock as rolled and as received from a steel mill.

In either event, the amount of steel present in the blank 1 equals the amount of steel to be present in the finished cold formed steel article since there is no scrap loss in carrying out the new cold shaping steps of the improved method. The steel used does not have to have a special or premium analysis as any ordinary carbon steel with a carbon content ranging up to, say, 0.40% carbon steel is satisfactory.

If the starting blank 1 is a scrap-slug-punching, its outer periphery is not cylindrical or truly concentric because of the presence of characteristic sheared surface roughness as indicated at 3 and the top and bottom surfaces thereof are not necessarily parallel plane sur-

faces. If the starting slug 1 is a disc cut from bar stock, it similarly may be slightly out of round or have slight diameter variations which conditions are usually present in bar steel as received from the steel mill. In either event, it is necessary to eliminate these variations or defects in the starting blank to preclude die injury or the formation of imperfect articles in subsequent operations; and accordingly, the first step in the new procedure is a slug sizing operation for providing a truly concentric blank and to eliminate dimensional variations which may be present in the starting blank 1.

In accordance with the present invention, the starting blank 1 is placed in a slug sizing die generally indicated at 4 in Figs. 2 and 3. Die 4 is formed with a cavity 5 therein which has an upper cylindrical portion 6 provided with a rounded upper corner 7 and connected by an angular shoulder 8 with a reduced cylindrical portion 9 which may be slightly tapered for draft (not shown). The cavity 5 is formed below the reduced cylindrical portion 9 with a second tapered shoulder 10 merging with a further reduced cylindrical portion 11, terminating in an angular shoulder 12 and a further reduced cylindrical portion 13. A knock-out member 14 having a top surface 15 is movable in cylindrical portion 13.

A punch generally indicated at 16 is associated with the die 4 and has a main cylindrical shank 17 which has a close sliding fit within cylindrical portion 6 of die cavity 5 so that the punch is centered and guided in its movement within die cavity 5. The rounded corner 7 on the die cavity insures proper entry and alignment of punch 16 in die 4 when performing a cold working operation after starting blank 1 has been inserted in die 4. The punch portion 17 terminates in an angular nose portion 18 which in turn terminates in a further tapered end portion 19 formed with a flat or slightly crowned end or bottom nose wall 20.

After blank 1 is inserted in die 4, a shown in Fig. 2, punch 16 is moved downward and engages the top of the blank, the location of the punch at this time being shown in Fig. 2. Continued downward movement of the punch applies a compressive force thus driving the blank downward in die cavity 5. The tapered end portion 19 of punch 16 enters the metal in the top of the blank and forms a central flat bottomed recess 21 in the top surface of the blank surrounded by a tapered annular shoulder 22 formed by the tapered end portions 19 of punch 16.

As punch 16 moves downward the compressive force exerted on the metal in the blank by punch nose 20 acting on the top of blank 1 causes the blank metal to flow and fill out the portions of the cavity 5 defined by portions 9, 10, 11 and 12 as shown in Fig. 3. The compressive force exerted by punch 16 in driving blank 1 downward in die cavity 5 reduces the various diameters of the outer periphery of the blank. The metal flow is accompanied by axial thickening of the blank more particularly in the vicinity of its axis, although the blank may be reduced in thickness at the axis itself, and by a small amount of backward extrusion in the upper annular corner 23 of the blank surrounding tapered annular shoulder 22. A prepared or sized blank 24 is thus formed which may be ejected from die cavity 5 by knock-out member 14 upon withdrawal of punch 16.

The cold working of blank 1 to form prepared blank 24 thus accurately sizes the periphery of prepared blank 24 under compression to be truly round, thereby removing all out-of-roundness or lack of concentricity that may have been present in blank 1 and also removing the characteristic sheared surface roughness 3 of blank 1 if the same was a scrap-slug-punching. The cold working also forms an annular shoulder 25 in the side walls of prepared blank 24 intermediate the ends thereof, this shape being imparted by tapered shoulder 10 of die cavity 5.

As blank 1 is driven downward in die cavity 5 and its diameter reduced to obtain concentricity and axial thickening, there may be some slight forward extrusion of metal in the lower outer annular regions of the blank from and below shoulder 25. However, such forwardly extruded metal region in the lower portion of the blank 1 is primarily subjected only to radial inward compression exerted by die shoulder 10 as a reaction to the downward compression of the punch on the top of blank 1, which produces a slight concavity in the bottom of the blank. The final shape of this concavity, indicated at 26 in Fig. 11, is produced by die cavity shoulder 10 which provides the adjacent forwardly extruded metal region in the lower portion of the blank by the radial inward compression exerted by die shoulder 10, all of which puts the grain in the lower portion of the blank under compression.

If it should happen that the bottom surface of the blank 24 has convexity rather than concavity imparted thereto, the convexity indicates that the grain in the metal in the bottom region of the blank in all probability has opened up; the concavity 26, indicating to the contrary, that the grain is closed or compressed as a result of compression. It is noted further that no axial squeezing pressure is applied to the blank 1 entirely between the top and bottom, as the completed blank 24 does not bottom on top of knock-out member 14. If any squeezing pressure were applied as by bottoming the blank 24 on knock-out member 14, the grain in the lower region of the blank might be opened up.

The metal in blank 24 in the region immediately below flat bottomed recess 21, indicated at 27, is cold worked to a somewhat

greater degree than the metal in the annular zone of blank 24 surrounding region 27 and between shoulder 25 and upper peripheral corner portion 23 due to the downward pressure of the flat bottomed punch nose 18. Blank 24 has a reduced diameter indicated at 28 in the lower portion of the blank below shoulder 25 imparted by the reduced cylindrical portion 11 of die cavity 5. The reduced diameter portion 28 of blank 24 terminates at its lower end in an annular angled corner portion 28*a* imparted by the angular shoulder 12 of die cavity 5.

The metal in the region of the reduced diameter portion 28 and angular corner 28*a* of blank 24 is cold worked to some degree by the radial inward compression thereof. Thus the cold working of the metal in the zones 27, 28 and 28*a* of the blank imparts work hardening to the metal. However, the metal in the remainder of blank 24 is only cold worked to a slight extent and is not appreciably worked hardened so that it may be subjected to substantial further cold working in subsequent operations.

In forming the truly round prepared blank 24, the central flat bottomed recess 21 and the surrounding tapered annular shoulder 22 at the top peripheral edge are also formed concentric with the truly round annular side wall surface of the blank; and the inward or lateral radial squeezing of the blank metal below the shoulder 25 seals any seams or flaws that may have been present in the metal in the lower region of starting blank 1 either as a result of the shearing operation which formed the blank 1 as a scrap-slug-punching, or as a characteristic of the bar as rolled by a steel mill from which starting blank 1 may have been cut.

The angular shoulder 8 in die cavity 5 enlarges the die cavity above cylindrical portion 9 for three purposes. The first is to provide a larger cylindrical portion 6 in die cavity 5 for strength, rigidity and stability of punch portion 17 received therein. The second is to provide for freely receiving out-of-round and variable dimensioned starting blanks 1 above the tapered shoulder 8 in die cavity 5. The third is to provide a shoulder past which the slug is driven in reducing its diameter for sizing the same.

Thus the operation illustrated in Figs. 2 and 3 is essentially a combination sizing and blank preparing operation, performed by cold working blank 1 under axial and radial compression by punch nose 20 in reduced die cavity portions 9—10, resulting in decreasing the diameter and increasing the thickness or height of prepared blank 24 with respect to starting blank 1.

The prepared or sized blank 24 is now ready for the next operation to form the same to cup shape. This operation is essentially a backward extrusion operation and may be performed in the die arrangement illustrated in Figs. 4 and 5. This die arrangement includes a die generally indicated at 29 formed with a cavity 30 therein having an upper cylindrical portion 31 provided with a rounded upper corner 32. The cylindrical portion 31 is connected by an angular shoulder 33 with a reduced cylindrical portion 34 terminating in an angular shoulder 35 and a further reduced cylindrical portion 36. The bottom wall of die cavity 30 is formed by a support member 37 which also serves as a knockout member, the top of support member 37 being formed with a flat surface 38.

A punch generally indicated at 39 is associated with die 29 and has a main cylindrical shank 40 which has a close sliding fit within cylindrical portion 31 of die cavity 30 so that the punch is centered and guided in its movement within die cavity 30. The rounded corner 32 on the die cavity insures proper entry and alignment of punch 39 in die 29 when performing the backward extrusion operation on a prepared blank 24 inserted in die 29. The punch shank 40 is joined by a tapered shoulder 41 with a cylindrical nose 42 having a flat bottom 43 joined with cylindrical nose portion 42 by a rounded corner 44.

After blank 24 is inserted in die 29, as shown in Fig. 4, punch 39 is moved downward and engages the top of flat bottomed recess 21 of blank 24, the location of the punch at this time being shown in Fig. 4. Continued downward movement of punch 39 within die cavity 30 applies a compressive force to the blank below the flat bottom 43 of the punch nose 42.

The size and shape of die cavity portions 31, 33, 34 and 35 above support member 37 are substantially the same as the size and shape of the lower portion of die cavity 5 illustrated in Figs. 2 and 3 so that blank 24 fits within the die cavity upon insertion therein. However, because support member 37 closes off the bottom of die cavity 30, as punch 39 moves downward, the metal in the blank below punch nose 42 moves downward until the concave portion 26 of blank 24 becomes flat and contacts flat surface 38 of support member 37.

At this time, the metal in the lower end of the blank is confined and cold worked and as punch 39 continues to move downward the metal in the blank extrudes backward or upward around punch nose 42 until the tapered shoulder 41 on the punch approaches tapered annular shoulder 22 of blank 24, when punch 39 is at the downward limit of its movement as shown in Fig. 5. During such backward extrusion, shoulder 25 of blank 24 also is relocated upward as at 46 in the resulting cup-shaped blank 47 (Figs. 5 and 12) formed by the operation illustrated in Figs. 4 and 5.

The extruded cup-shaped blank 47 thus

formed may be ejected from die cavity 30 by support member 37 upon withdrawal of punch 39. The extruded blank 47 (Fig. 12) has a cup formation with a flat bottom wall 48, a lower annular side wall portion 49 below shoulder 46, a lower angular corner 45, and an upper thicker annular side wall portion 50 above shoulder 46 forming a central recess 51. The upper annular end of side wall portion 50 at the top of recess 51 is formed with a tapered annular shoulder 52 corresponding to tapered shoulder 22 in blank 24 and shoulder 52 merges by portions 53 and 54 with the outer annular side wall surface 55 of side wall portion 50.

During downward movement of punch 39, as the blank metal flows outward from beneath punch nose 42 and then extrudes backward or upward, and as bottom flat surface 43 of punch nose 42 approaches a position opposite angular die shoulder 33 at the limit of its movement as shown in Fig. 5, relocated blank shoulder 46 moves upward away from die shoulder 33 indicated by clearance space 56 in Fig. 5.

During the cold working of blank 24 to form cup-shaped blank 47, the metal in certain portions of the blank is worked severely while metal in other portions of the blank is worked less severely. Thus the metal in bottom wall 48 of blank 47 and in lower side wall portion 49 and angular corner 45 below shoulder 46 is severely cold worked to substantially the limit of its workability and the desired hardness is developed in this portion of the blank. However, the metal in the upper side wall portion 50 of the blank 47 is less severely cold worked and may be further cold worked by subsequent operations.

Referring to Figs. 10, 11 and 12, and to the sizes and shapes respectively of blanks 1, 24 and 47, the relatively large outer diameter of blank 1 has been reduced under compression to the smaller diameter of bottom and side wall portions 48 and 49 of blank 47 below shoulder 46, and bottom wall 48 is substantially thinner than the axial thickness of blank 1 in the portion in the vicinity of its axis. Thus, in the operations thus far described, starting blank 1 has been decreased in size and formed with reduced thickness, at least in its lower portion, by the successive cold working operations performed thereon depicted in Figs. 2, 3, 4 and 5.

Similarly, internal cavity or recess 51, and internal shoulder 52 at the top of cavity 51, and external shoulder 46 intermediate the ends of the side walls of blank 47 have been formed by the successive cold working operations performed. The formation of angular annular shoulder 52 at the top of the blank recess 51 is of special importance, with relation to angular shoulder 46, in the procedure of the present invention for reasons presently to be explained.

Furthermore, the cooperative relation of punch 39 and die 29, and punch nose 42 and angular shoulder 22 in cup-shaped blank 24 form the recess 51 and shoulder 52 to be truly concentric with the remaining portions of blank 47.

The extruded blank 47 is now ready for the next operation to elongate the axial length and reduce the radial thickness of upper side wall portion 50 of the blank. This operation may be performed in the die arrangement illustrated in Figs. 6 and 7 which includes a die generally indicated at 57 formed with a cavity 58 having an upper tapered portion 59 and a lower cylindrical portion 60, terminating in a sharp corner 61, above a larger cylindrical portion 62 in lower die member 63. There is no bottom wall for the die cavity 58 as such, but a support member 64 may operate in enlarged cylindrical portion 62 for receiving the work piece worked in die 57 below sharp corner or shoulder 61.

A punch generally indicated at 65 is associated with die 57 and has a main cylindrical shank 66. The punch shank 66 terminates at corner 67, and an angular shoulder 68 connects shank 66 with a cylindrical nose or pilot portion 69. A narrow flat annular band 70 connects corner 67 at the bottom of punch shank 66 with the upper annular intersection of tapered shoulder portion 68.

Referring to Figs. 6 and 7, the diameter of die cavity portion 60 is substantially the same as the diameter of blank 47 at outer annular side wall surface of lower annular side wall portion 49 so that when a blank 47 is inserted in die 57, as shown in Fig. 6, the blank is centered and snugly fits in said die portion 60 with blank shoulder 46 resting on die tapered portion 59. Thus blank 47 is accurately centered in die 57 and after insertion therein, punch 65 moves downward and punch pilot portion 69 telescopes within blank recess 51 with the bottom of punch nose 69 contacting the bottom 48 of blank recess 51 and with annular clearance between the side wall of recess 51 and side surface of punch nose 69 as shown in Fig. 6. At this time the punch shoulder 68 does not contact the blank shoulder 52.

The punch 65 continues to move downward within die cavity 58 and nose 69 pushing on bottom wall 48 of blank 47 forces blank 47 downward through restricted cylindrical portion 60 of die cavity 58. Since the outer diameter of the lower annular side wall portion 49 of blank 47 below shoulder 46 is the same as the diameter of die cavity portion 60, no work is performed on the metal in the lower portion of the blank but the metal in the blank commencing at the extreme lower portion of shoulder 46 is drawn and ironed as blank 47 is pushed through the die cavity portion 60, accompanied by elongation of the metal in the upper portion of the side walls of the blank

and a reduction of the internal diameter of blank recess 51 until this diameter becomes the same as the diameter of punch nose 69.

The metal in the side walls of blank 47 continues to elongate until tapered blank shoulder 52 moves upward relative to punch nose 69 and contacts tapered angular shoulder 68 of punch 65, whereupon continued downward movement of punch 65 applies a compressive force at the upper end of blank 47 through punch shoulder 68 to blank shoulder 52.

Up to this time, the metal in the blank side walls annularly between punch nose 69 and die portion 60 is drawn and ironed. However, when the compressive force is applied to blank 47 through punch shoulder 68 to blank shoulder 52, the metal in the upper portion of the side walls of blank 47 is extruded upward between downwardly moving punch portions 67, 68, 69 and 70 and die portions 60 and 59, resulting in further axial elongation of the blank.

As punch 65 continues to move downward, and as punch corner 67 passes through die portion 60, cold working of the metal in the upper region of the blank changes from backward extrusion to drawing until the blank is pushed completely through die portion 60 to the position shown in Fig. 7. During the last stages of the operation, the backward extrusion and upward drawing of the metal in the upper region of the side walls of the blank forms the metal upward around punch portion 66 to form a thin annular terminal side wall portion 71 in resulting blank generally indicated at 72.

This thinner annular side wall portion 71 in blank 72 extends upward from the thicker side wall portion 73 surrounding recess 74 which extends downward to blank bottom wall 75. The upper thin terminal end portion 71 of blank 72 also extends upward from tapered shoulder 76 at the top of recess 74 beyond a band-like annular shoulder 77 lying in a plane normal to the axis of the blank 72, formed by the flat annular band 70 on punch 65 connecting between square punch corners 67 and tapered punch shoulder portion 68.

As blank 47 is pushed through die cavity 58 in the manner described, the blank metal is cold worked, drawn, extruded and ironed under axially applied pressure, and as the formed blank 72 leaves die cavity 58 there is a reaction as a result of such compression working of the metal in the blank such that the diameter of resulting blank 72 increases slightly in the order of up to about .005".

Thus, referring to Fig. 7, after punch 65 reaches its limit of downward movement as shown, it may then be retracted and blank 72 is stripped therefrom because the upper end of blank terminal portion 71, now of larger diameter, engages die corner 61 preventing further upward movement of blank 72. The blank 72 thus drops from punch 65 onto support member 64 which may be lowered for discharging blank 72. It is unnecessary to use a support member 64 in all cases and alternatively the blank 72 may drop to a discharge chute. In this manner, according to the present invention, no mechanical device is required to strip formed blank 72 from punch 65. It is noted further that the larger the diameter of formed blank 72, the greater will be the expansion reaction thereof after blank 47 is pushed through die cavity 58.

Blank 72, (Fig. 13) now has a uniform exterior diameter substantially the same as the diameter of lower portion 49 of blank 47, and an internal recess 74 similar to but deeper than recess 51 in blank 47 produced by the elongation of the metal in the side walls of upper annular portion 50 of blank 47. The bottom wall 75 of blank 72 is not affected in the operation shown in Figs. 6 and 7 because the metal therein was previously cold worked substantially to the limit of its workability. The metal in the side wall portion 73 of blank 72 surrounding recess 74 is also cold worked substantially to the limit of its workability by the same operation.

During the draw-through operation just described, the internal diameter of the side walls of recess 74 in blank 72 is slightly reduced during the cold working of metal in the blank, its shape and size being imparted by the shape of punch pilot portion 69. The diameter reduction is equivalent to the annular clearance space shown in Fig. 6. The side walls 73 of blank 72 again are truly concentric and absolutely uniform in thickness because of the cooperative relation of punch 65 and die 57, and punch shoulder 68 and blank shoulder 52. Similarly, thinner terminal side wall portion 71 has uniform thickness and is concentric with the remaining portions of the blank.

Accordingly, the operation illustrated in Figs. 6 and 7 completes the cylindrical formation of the blank 72, eliminates the outer shoulder in the side walls thereof and reforms the side wall thickness to be uniform surrounding recess 74 and below inner angular shoulder 76 and to be uniform and thinner above angular shoulder 76.

Of special importance in the draw-through operation shown in Figs. 6 and 7, is the engagement of tapered shoulder 68 on punch 65 with tapered shoulder 52 of blank 47 which pushes the blank through the die opening to backwardly extrude and then draw metal in the side walls of the blank 47 to produce a cylindrical blank 72 of exact height from bottom of cavity 74 to shoulder 76.

Of further importance in the draw-through operation shown in Figs. 6 and 7 is the provision of the sharp corner 67 at the bottom of punch shank 66 at the outer annular edge of the narrow flat annular band 70 that connects corner 67 with the intersection of

tapered shoulder portion 68. As tapered shoulder 68 exerts pressure on tapered shoulder 52 of blank 47 to push the blank through die cavity 58, the square corner 77 is formed in resulting blank 72 surrounding tapered shoulder 76 at top of recess 74 so that the blank is absolutely uniform in thickness and concentric throughout. If there is any unevenness in the metal in the side walls of the blank as the same is drawn and extruded as described, this unevenness is carried to the upper end of the terminal thin annular side wall portion 71 of blank 72 to impart slight variations in the length of portion 71, which variations, however, do no harm because the same may be eliminated in subsequent operations.

In some instances the cylindrical blank 72 may constitute the finished cold worked product which may be threaded, if desired, either in internal portions or external portions, or both, depending upon its ultimate use. Alternatively, the blank may be further cold worked as shown in Figs. 8 and 9 by a typical nosing operation. If the metal in thin terminal annular wall portion 71 of blank 72 has been worked to the limit of its workability, then this metal may be locally heat treated to permit further cold working thereof. In any event, blank 72, if desired, may be inserted in cavity 78 of nosing die 79 having a cooperating nosing punch 80 as shown in Fig. 8. As punch 80 moves downward to the position shown in Fig. 9, upper annular terminal wall portion 71 of blank 72 is nosed or necked inward and somewhat thickened or elongated as shown at 81 in the finished cold worked blank 82 (Figs. 9 and 14). Upon completion of the operation, punch 80 may be raised and completed blank 82 ejected by knock-out member 82*a*. In nosing the blank 72, the sharp corner 77 locates the bend point for the nosed-in terminal wall portion 81.

Here again the finished cold worked blank 82 may be internally threaded at 83 and undercut as indicated at 84 in Fig. 15, by usual machining operations, to provide the finished inserting plug or fitting illustrated in Fig. 15 by way of example only. Above the threaded portion 83, an angular shoulder 85 is still present terminating in the thinner annular terminal wall 81.

As a further alternative, blank 72 of Fig. 13 may be further cold worked to form a finished article 86 illustrated in Fig. 16 in which the thin terminal annular wall portion 71 of blank 72 is turned or flanged outward as indicated at 87 by a usual flanging operation.

One of the characteristics of the present invention is the initial formation of the angular shoulder 22 in sized blank 24 which ultimately becomes the shoulder 76 or 85 in the finished product (Figs. 13, 14 and 15). As indicated, this shoulder in cooperation with the external shoulder intermediate the ends of the blank in certain stages, not only permits the progressive flow and cold working of the metal in the blanks during successive steps but also aids in maintaining concentricity of the various portions of the blank in successive stages from the sized blank 24 to the finished product 72 or 82 or 86.

In connection with all of the cold working operations illustrated, normal press or die lubricants are used, and the starting blank for each operation is preferably bonderized or provided with a usual phosphate coating to assist in holding the lubricant on the surface of the blank.

Although in the successive blanks and operations illustrated, it is unnecessary to carry out any intermediate annealing or normalizing, it may be necessary in some instances, depending upon the size and shape of the resultant product, to use an intermediate annealing or normalizing operation after blank 24 is formed or in a two stage formation of blank 47 before final formation thereof. Where such operation is used, it is understood that the blank would then be pickled and washed in the usual manner prior to bonderizing the blank in preparation for the next operation. Likewise, in some instances it may be desirable to perform a final stress relief heating at, say, about 750° F. The same type of localized stress relief heating may also be performed prior to the nosing or necking-in operation of Figs. 8 and 9.

Accordingly, the present invention provides a new procedure and die arrangement for the manufacture of steel articles including cold forming in which manufacturing costs are reduced, scrap products may be used as starting blanks, and metal flow is directed and controlled in various stages to provide a steel plug or fitting with tubular side walls of different or varying thicknesses the manufacture including the formation of a cup-shaped article having an annular internal shoulder adjacent its open end and with a thinner annular terminal side wall above the shoulder; provides a cold working procedure for producing the described steel product without metal loss; accomplishes the many new features hereinabove described; and overcomes many prior art difficulties and solves long-standing problems in the art.

Thus in the preferred embodiment the invention involves progressively working the metal in the blank first in the central regions thereof and later in peripheral regions thereof to reduce the diameter and elongate the side walls of the blank to the desired shape in such manner that when the desired shape and hardness have been developed in any region or zone of the blank by cold working, that zone of metal is not further cold worked in subsequent steps.

The method of the present invention may

be applied to making a hollow internally shouldered steel plug or fitting having strong and dense metal walls of desired hardness from a low carbon steel starting blank or slug without any scrap loss incident to the cold forming of such article.

Moreover, the present invention provides a way in which a hollow plug product can be made by cold forming to provide a sound, strong, leakproof and pressure resistant plug or fitting having the desired cross sectional configuration, without the metal mass loss usually incident to the forming of the article from a slug of metal of substantially different shape.

By the use of dies of a particular design and by co-ordinating and relating a series of steps in the cold working of a generally round scrap-slug punching or its equivalent in size and amount of metal, having a thickness less than one-half the diameter thereof, having a diameter greater than the diameter of the finished plug or fitting, and having a thickness which may be the same or greater than the thickness of the bottom wall of the finished plug, and having a thickness substantially less than the height of the finished plug, a plug or fitting of the type described may be produced and a desired finished shape and required strength and hardness obtained by cold working.

The procedure in the preferred embodiment involves the control of the character, location and direction of metal flow in the blank as it is subjected to cold working under compression in successive stages, so that the metal is relocated in the blank without rupture or fracture to form the desired shape in the finished article.

In the foregoing description certain terms have been used for brevity, clearness and understanding; but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such terms are utilized for descriptive purposes herein and not for the purpose of limitation and are intended to be broadly construed.

Moreover, the description of the improvements is by way of example and the scope of the present invention is not limited to the exact details illustrated, or to the specific articles shown, or to the uses of the articles described.

WHAT WE CLAIM IS:—

1. A method of cold forming a steel article having a tubular side wall and a bottom wall and having an internal angular annular shoulder and an annular terminal wall portion above the shoulder and thinner than the side wall portion below the shoulder, which comprises pushing through a restricted opening a cup shaped blank having a central cavity with a bottom wall, an annular side wall and an angular annular shoulder at the open end of the side wall, by applying a pushing force to the cup bottom wall to push the cup shaped blank through said restricted opening thereby drawing, elongating and thinning the cup side wall between the bottom wall and said angular annular shoulder, continuing to push the cup bottom wall until the cup side wall has been elongated sufficiently to establish a predetermined height from the cavity bottom wall to said angular annular shoulder, and then applying axial pressure to said angular annular shoulder to first rearwardly extrude metal from the cup side wall to form said terminal wall portion above said shoulder and then to draw and elongate the metal in said terminal wall.

2. The method as claimed in claim 1 including the prior step of forming said cup-shaped blank by cold working a disc like steel starting blank by axially pressing and radially squeezing said starting blank to size the same to be truly concentric and to form said angular annular shoulder surrounding a concentric recess in the top of the blank, and then axially squeezing the sized blank to form said cup-shaped blank.

3. The method as claimed in claim 2 in which said axially pressing and radially squeezing also forms a concaved surface in the bottom of the blank, and in which the axial squeezing of the sized blank is effected between the recess and the concaved surface, and in which the annular side wall of the cup-shaped blank so formed is provided with an inner cylindrical surface whose diameter is reduced when the cup-shaped blank is pushed through said restricted opening.

4. A method of cold working a solid steel blank which comprises the steps of providing a disc-like steel starting blank, successively subjecting the blank to a series of axial compressions while laterally confining the same to progressively decrease the diameter of the blank and to first increase and then decrease the axial thickness of the blank in the vicinity of its axis and to form a cup-shaped article with tubular side walls, initially forming an angular annular shoulder in the top surface of the blank during the first axial pressure application, maintaining said angular annular shoulder throughout subsequent axial pressure applications, during which pressure applications side walls are formed in the blank, and, during the last stages of the final axial pressure application, pressure being applied to said shoulder to rearwardly extrude and draw metal from the blank side walls to form a thin annular terminal side wall portion above said shoulder to produce a finished cylindrical cup-shaped article with tubular side walls terminating in a thin annular portion.

5. A method of cold working a disc-like solid steel blank to form a tubular article as hereinbefore particularly described and with reference to and as illustrated in the accompanying drawings.

6. Tubular steel articles made by the method claimed in any preceding claim.

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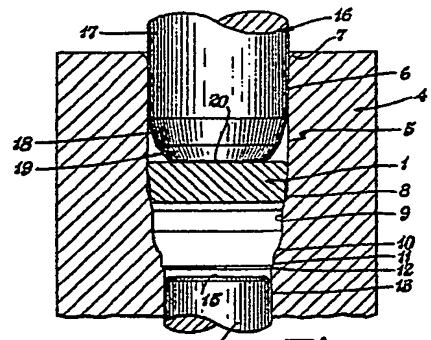


Fig. 2

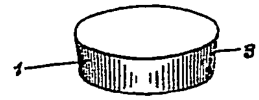


Fig. 1

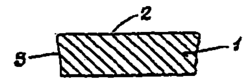


Fig. 10

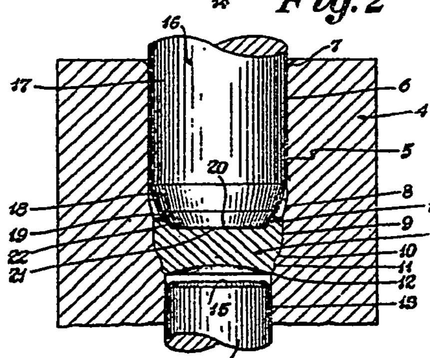


Fig. 3

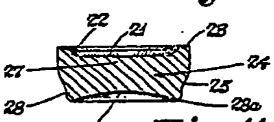


Fig. 11

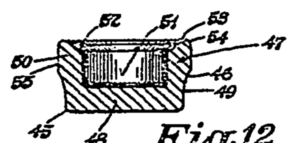


Fig. 12

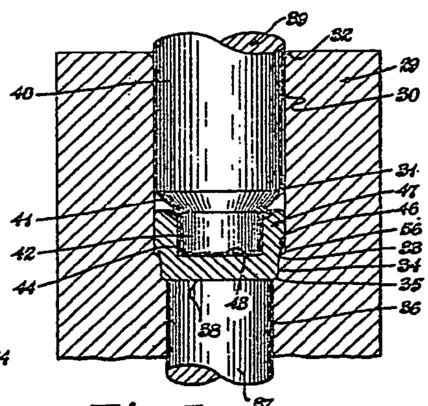


Fig. 5

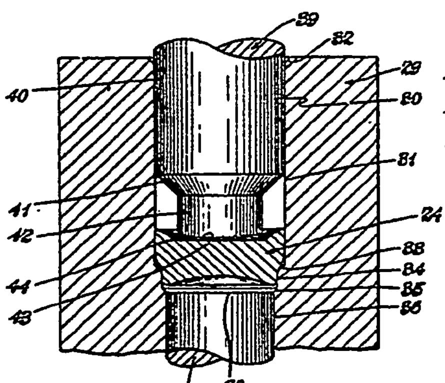
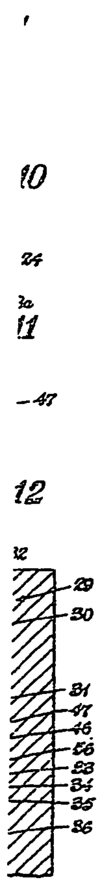


Fig. 4



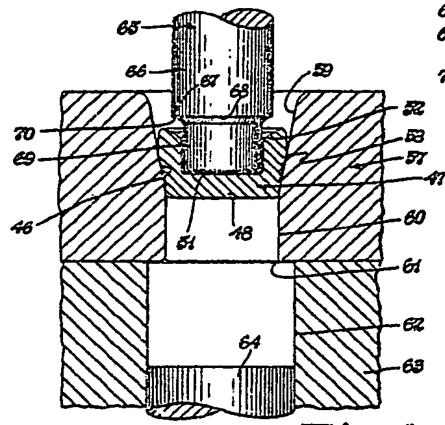


Fig. 6

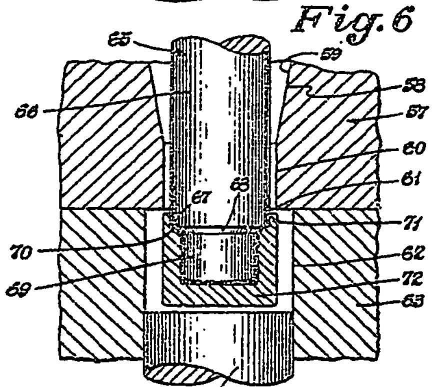


Fig. 7

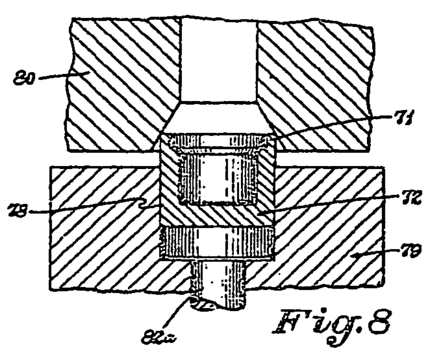


Fig. 8

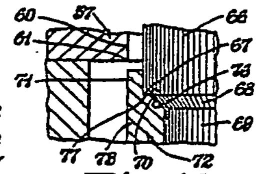


Fig. 17

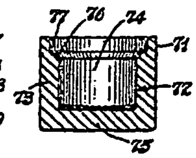


Fig. 13

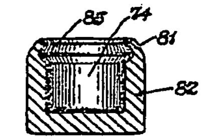


Fig. 14

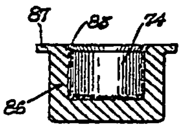


Fig. 16

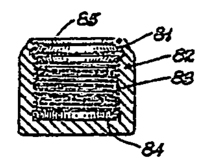


Fig. 15

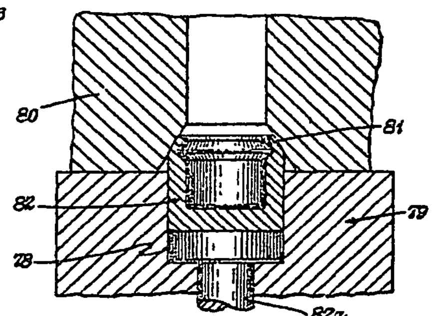


Fig. 9

806,387 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEETS 1 & 2

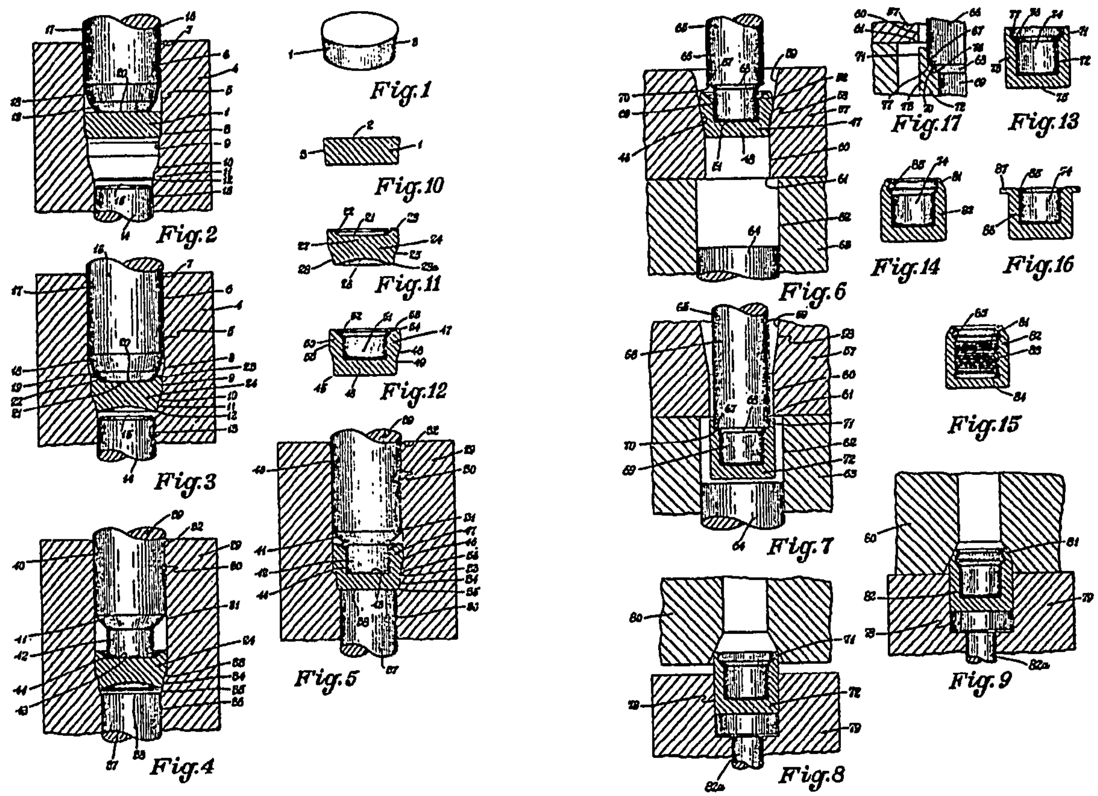


Fig.1 Fig.2 Fig.3 Fig.4 Fig.5 Fig.6 Fig.7 Fig.8 Fig.9 Fig.10 Fig.11 Fig.12 Fig.13 Fig.14 Fig.15 Fig.16 Fig.17